Proton Induced Radioactivity in Oxygen

As previously reported[1, 2] a large number of elements are found to become radioactive under bombardment by protons of energies up to 3.8 Mev. Two periods have been definitely established for oxygen, using targets of quartz and other solid oxides as well as a platinum foil in oxygen. The short period of 1.28 ± 0.10 min. is at once identified with the well-known F^{17} formed by the capture of a proton by O^{16}. The activity becomes detectable at a proton energy of 1.4 Mev rising rapidly to about 3 Mev and then more slowly (thick target).

The second period of 107 ± 4 min. is shown by chemical separation to be due also to an isotope of fluorine and is close to the 112 min. period found by Snell[3] for F^{18}. This period must be attributed to the reaction

$$O^{18}+H^1\rightarrow F^{18}+n^1$$
$$F^{18}\rightarrow O^{18}+e^+.$$

All other oxygen reactions lead either to stable isotopes or to known and much shorter periods. The presence of neutrons expelled during bombardment was proved by the activity induced in a silver plate imbedded in paraffin.

This proton-neutron type of reaction has not been previously reported since disintegration experiments with protons have hitherto been confined to energies below about 1.2 Mev. The above reaction sets in sharply at 2.6 Mev and rises so rapidly that at 3.8 Mev the F^{18} activity is much stronger than the F^{17} in spite of the low abundance of the O^{18} isotope. Rough calculations of the cross section give a value of 4×10^{-25} cm^2 which is 4000 times greater than for the O^{16} capture reaction.

It is easily seen that for any proton-neutron reaction of this type where the initial and final stable isotopes are the same, the reaction becomes energetically balanced for protons of energy given by

$$E_p=n^1-H^1+e^++(e^-)+E_++E_n,$$

where E_n is the kinetic energy of the neutron and E_+ the maximum energy of the positrons. For F^{18} the latter has been found to be about 0.6 Mev which gives for the threshold, assuming here the neutrons escape with negligible energy,

$$E_p=0.81+1.02+0.6=2.43 \text{ Mev}$$

in good agreement with the observed threshold of 2.6 Mev.

It seems probable that this type of reaction is taking place in a number of the other elements studied. In particular for the Mn reaction (90 min. period) previously reported[1] this appears to be the only possibility. The deuteron emission first suggested is energetically excluded in this case and subsequent chemical tests indicate the reaction

$$Mn^{55}+H^1\rightarrow n^1+Fe^{55}\rightarrow n^1+Mn^{55}+e^+.$$

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[1] Barnes, DuBridge, *et al*, Phys. Rev. **51**, 775 (1937).
[2] Washington Meeting, 1937.
[3] Snell, Phys. Rev. **51**, 143 (1937).

Scattering of Fast Neutrons

The elastic cross sections of heavy nuclei for beryllium-radon neutrons have been recalculated for the same approximate interaction between neutron and nucleus considered previously[1] using the larger value for the nuclear radius suggested recently by Bethe.[2] Fig. 1 shows

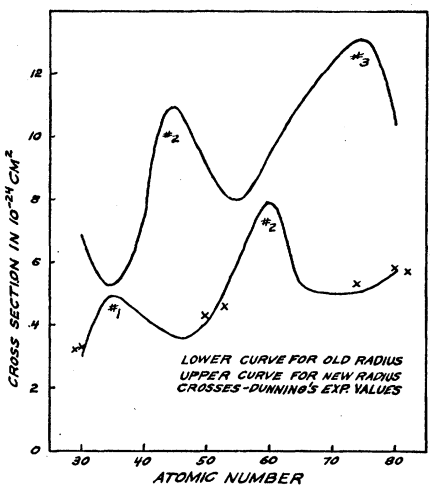

FIG. 1. Scattering of Be—Rn neutrons.

the results for both old and new radii. The partial cross sections responsible for the maxima are indicated.

The new radius is seen to give cross sections too high compared with the experimental values of Dunning.[3] If Bethe's larger radius is not to be rejected it must be shown that the polarization effects neglected in our treatment of the nucleus as a single particle operate consistently to reduce the cross section for fast neutron scattering. The Bohr "water-drop" model of the nucleus, so useful in affording a qualitative explanation of large capture cross sections for slow neutrons, does not appear to give an obvious answer to this question.

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May 14, 1937.

[1] Fay, Phys. Rev. **50**, 560 (1936).
[2] Bethe, Phys. Rev. **50**, 1100(A) (1936).
[3] Dunning, Phys. Rev. **45**, 586 (1934).

Long Period Activity in Cadmium Irradiated with Neutrons

Recently Cork and Thornton[1] bombarded cadmium with 6.3 Mev deuterons and found two activities due to cadmium with periods of 4.3 hr. and 58 hr., respectively. The radioactive isotope of cadmium of 58 hr. period gives rise to a radioactive indium isotope of 2.3 hr. half-life. The two active cadmium isotopes are Cd^{115} and Cd^{117} which can be formed from Cd^{114} and Cd^{116} by neutron capture. Since no activity has thus far been produced in Cd by neutron bombardment, it was thought worthwhile to see if it would be possible to activate Cd in this manner.

A neutron source, consisting of 200 mC radium salt mixed with beryllium was surrounded by blocks of paraffin.